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Technical Report

DRAFT

Guidance on Estimating Motor Vehicle Emission Reductions From the Use of Alternate Fuels and Fuel Blends

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1.0 INTRODUCTION

1.1 Purpose

This document provides methods and assumptions for estimating the impact of use of alternative fuels and fuel blends on motor vehicle emissions. The information is presented in a format which assumes it will used by State and local air quality planning agencies in preparing current and future emissions inventories and emission reduction strategies during 1987, 1988, and 1989. Such planning efforts will be necessary in areas which receive calls from EPA for revisions to their ozone or CO State Implementation Plans (SIP) following their failure to attain (or in a few cases to provide for attainment in a prospective sense) the National Ambient Air Quality Standards (NAAQS) for these pollutants. As of the publication date of this report, EPA has not yet proposed specific requirements applicable to these SIP calls, but is expected to do so in the Federal Register by the fall of 1987. While the details of the requirements are not known, it is certain that many affected areas will need to estimate current and future year motor vehicle emissions. Use of alternative fuels and fuel blends is likely to be part of future scenarios that will be examined in many areas.

Adherence to the methods and assumptions in this document when preparing SIP revisions will facilitate EPA review and avoid the need for States to justify those aspects of their analysis. Differing assumptions and methods, if used, will be subject to closer and more questioning EPA review. In all cases, final EPA approval or disapproval of a particular State's SIP revision occurs only after notice and opportunity for public comment, including any comments on the methods and assumptions recommended here.

While not specifically addressed, the information in this document may be useful for estimating the emissions impact of smaller scale use of alternative fuels than might be contemplated in a SIP revision.

The reader is warned that the methods described in this document have not been cast into the form of a self-contained computer model or single look-up table. At the present time, hand calculation and transcription of intermediate results is necessary. The resourceful planner may be able to automate these steps, however.

1.2 Alternative Fuels Addressed

Separate information is provided for the following fuels or types of fuels. In some cases cross references are made between fuels to avoid repetition of numerical information that can apply to more than one fuel.

- 10% ethanol blends (gasohol).
- Methanol blends (including DuPont and Oxinol).
- Methyl Tertiary Butyl Ether (MTBE) blends.
- Retrofit of gasoline vehicles to achieve dual-fuel gasoline /compressed natural gas (CNG) capability and new CNG vehicles.
- Newly manufactured "flexible fuel" vehicles capable of operating on gasoline/methanol mixtures ranging from 100% gasoline to 85% gasoline/15% methanol.
- Newly manufactured vehicles designed for operation only on a mixture with at least 85% methanol and employing "current" technology.
- Newly manufactured vehicles designed for operation only on 100% methanol and employing "advanced" technology.

1.3 Usage Scenarios Addressed; Tracking

This document addresses only the issue of individual vehicle effects when operating on an alternative fuel. A government program on alternative fuels could take a variety of forms with respect to requiring or encouraging the use of alternative fuels. A regulatory mandate to require certain vehicles to use one specific fuel is one approach. The following are some of the other forms a government program might take:

- A requirement that all fuel sold for use in gasoline vehicles have a minimum oxygen content. Depending on the oxygen content requirement, ethanol blends (gasohol), methanol blends, and MTBE blends might all compete and achieve a market share mix that depends on relative cost and local consumer attitudes and other conditions. Presently, a minimum oxygen content of anything more than 2% would preclude marketing of MTBE blends in unleaded fuel, since 2% oxygen is thelimit of EPA's "substantially similar" regulation.[14] The market share mix must be predicted to calculate the net effect on emissions since each of these three blends affects emissions differently.

- A requirement that each wholesaler (or each actor at a higher level of the marketing chain) achieve a certain average oxygen content in its product over some reporting period, with trading of oxygen "credits" among wholesalers. Such an "averaging with trading" approach would make it possible to specify a minimum average oxygen content greater than 2%, without necessarily forcing MTBE blends or even oxygen-free gasoline from the market, since wholesalers of these fuels may buy credits for their oxygen deficit and adjust their prices accordingly. This feature may be attractive to areas which desire larger CO emission reductions but which wish to preserve consumer choice. One complication would be the more elaborate record-keeping and enforcement program required to ensure compliance. As in the simpler example above, the market mix of fuel types must be forecast to estimate emission reductions.

- A requirement that certain types of fleets retrofit all newly purchased vehicles to operate on compressed natural gas.

- An initially voluntary but by agreement irrevocable and enforceable commitment by a large fleet to use an alternative fuel. This might be part of an emissions trade agreement, for example.

- An incentive program for use of one fuel or a group of fuels based on differences in State or local fuel taxes or vehicle sales taxes.

- A promotional program based solely on voluntary participation.

Predicting how many and which types of vehicles will use each type of fuel in response to a specific planned government program is an important step in estimating its effect on motor vehicle fleet emissions. This document does not attempt to provide standard assumptions on usage of alternative fuels. Instead, States must demonstrate a reasonable basis for their own estimates of fuel use by type. EPA technical staff are available to discuss such estimates before States invest heavily in analysis or planning based on them.

It is expected that EPA's forthcoming policy on post-1987 nonattainment will require affected areas to both adopt emission reduction measures <u>and</u> to report periodically to EPA on the status of their implementation efforts and on the year-to-year

changes in their emission inventory. If this inventory tracking system shows significant differences between the expected inventory trend and the trend that actually occurs, EPA will likely require some sort of corrective or offsetting action by the area. States which adopt an alternative fuels program, and receive EPA approval for emission reduction estimates based on predicted future usage levels as a result of that program, will be required to track and report on actual usage levels. Significant errors in prediction may require further revision of the SIP.

A final usage issue relates to seasonal requirements or incentives for alternative fuels and how to predict usage in the off season when use is not required or subsidized. For example, an area might require all gasoline-type fuels to contain a certain minimum level of oxygen only in winter months, but this may indirectly result in substantially higher use of oxygenated blends in summer months. Depending on a number of factors, summer time VOC emissions may be increased or decreased as a result. Areas adopting winter time alternative fuels programs should explicitly predict their effect, if any, on summer time VOC and hence on VOC reduction targets. This document can be used to estimate summer VOC effects, but only given an external prediction of fuel use by type. Each State must demonstrate a reasonable expectation that its prediction is accurate. EPA may require actual use in summer to be tracked and reported.

1.4 Organization

This document is organized as follows.

Section 2.0 provides some background on how motor vehicle emission inventories are estimated apart from the complications posed by alternative fuels.

Section 3.0 presents the core technical assumptions about the effect of each alternative fuel on various types of vehicles. These assumptions are for the most part not derived or defended in this document, but appropriate references to other documents are provided.

Section 4.0 explains how these core assumptions can be used to adjust the output of MOBILE3 to reflect an alternative fuel usage scenario of interest.

Section 5.0 gives instructions on how to obtain and use a special version of MOBILE3's FORTRAN code so as to achieve in practice the steps described in principle in Section 4.0.

2.0 BACKGROUND ON SIP INVENTORIES FOR MOTOR VEHICLE EMISSIONS

Except for California areas, EPA requires the motor vehicle emission inventories in all ozone, CO, and NO_2 SIP revisions to be based on the most recent available version of EPA's mobile source emission factor computer model. The current version is MOBILE3; MOBILE4 is under development and expected to be released in the fall of 1987, for use in preparing the SIP revision for which EPA will call in early 1988. MOBILE4 will be updated internally with new information, and will also allow planners to account for the influence of some factors not addressed by MOBILE3. Externally, MOBILE4 will resemble MOBILE3 and will be used in the same manner by planners. The discussion that follows will refer mostly to MOBILE3, but will apply to MOBILE4 also.

The function of MOBILE3 is to provide estimates of the average emission levels of in-use motor vehicles, expressed in grams per mile. The normal output provides average levels for each of HC (either total or non-methane at the user's direction), CO, and NO_x for each vehicle type and for all vehicle types averaged together. The following vehicle types are used.:

- light-duty gasoline vehicles (LDGV)
- light-duty gasoline trucks below 6000 GVWR (LDGT1)
- light-duty gasoline trucks between 6000 and 8500 GVWR (LDGT2)
- light-duty diesel vehicles (LDDV)
- light-duty diesel trucks below 8500 GVWR (LDDT)
- heavy-duty gasoline vehicles (HDGV)
- heavy-duty diesel vehicles (HDDV)
- motorcycles (MC)

A planner typically wishes to estimate motor vehicle emissions of a given pollutant for a certain city, an individual roadway, or a collection of similar roadway segments for a year, a day, or an hour. He or she would do this by making or obtaining an estimate of the number of vehicle miles traveled (VMT) in the geographic area and time period of interest and multiplying it by the gram per mile "emission factor" produced by MOBILE3.

To allow the planner to get an "emission factor" that is representative of the geographic area and time period under investigation, MOBILE3 allows the user to specify a number of input parameters to reflect local conditions. The more important of these factors are the following:

- o whether the area is at low or high altitude
- o the VMT split by vehicle type
- o for each vehicle type, the age mix of vehicle registrations
- o for each vehicle type, the mileage accumulation rate by age of vehicle
- o ambient temperature
- o average speed of the traffic in the area
- o the mix of cold versus warmed up vehicles
- o the features of any periodic vehicle inspection program operating in the area of interest
- o local tampering and misfueling rates
- o the calendar year of interest

The last item is very important since it determines the mix of vehicles designed to different emission standards and their age and therefore deterioration.

For every input parameter except calendar year, MOBILE3 (or its user's manual) provides a default value for users not wishing or able to use local conditions. The defaults generally represent summer time nationwide urban conditions.

The influence of some input parameters is very strong, and the overall emission factor output can vary by a factor of 3 or 4 or more by setting some inputs to extreme but still realistic values. Speed, temperature, and cold/warm mix are particularly influential. These inputs can affect the relative contribution of different vehicle types and vintage to the overall emission factor outputs, as well as its absolute level.

The default inputs to MOBILE3 are also the conditions of the official Federal Test Procedure (FTP) for vehicle emissions, which is used for regulatory purposes. The FTP conditions are also used in nearly all research projects involving vehicle emissions and factors that affect them. In particular, virtually all reliable data on the emissions effects of alternative fuels has been collected under these FTP

conditions. An important issue in assessing the impact of alternative fuels for SIP purposes is to provide a way to bridge between test data collected under FTP conditions and the local conditions facing individual SIP planners. This issue is addressed by the method presented in subsequent sections.

This document does not address how local inputs for MOBILE3 should be estimated, or methods for estimating VMT in a particular area and time period. EPA Regional Offices should be contacted for guidance in these areas.

3.0 PER-VEHICLE EMISSION REDUCTIONS WITH ALTERNATE FUELS

3.1 Oxygenated Gasoline Blends

3.1.1 10% Ethanol Blends (3.7% oxygen)

Much of the information in Section 3 is summarized from recent EPA reports on the effects of fuel volatility on vehicle emissions.[1,2] Much of the information also comes from analyses and test programs run by the Colorado Department of Health for exhaust emissions of vehicles at high altitude[3,4,5,6,7] and from statistical analyses of low altitude data performed by the EPA Office of Mobile Sources.[8,9,10,11,12,13] Much of the information in this section for ethanol blends is applicable to methanol blends and, to a lesser extent, MTBE blends both of which are discussed in later Sections (3.1.2 and 3.1.3).

3.1.1.1 Exhaust HC, CO and NOx Emissions

The use of an oxygenated fuel blend such as gasoline with 10% ethanol (gasohol) results in an enleanment (i.e., more oxygen for fuel combustion) due to the oxygen contained in the blend itself. Fuel metering devices on vehicles such as carburetors or fuel injectors (without an oxygen sensor or with an oxygen sensor but operating in the "open loop" mode where the sensor is not functional) usually meter fuel and air volumetrically. Thus, the oxygen in the fuel results in less fuel and more total oxygen reaching the engine for fuel combustion since the amount of air is not diminished. If the initial mixture on gasoline is rich of stoichiometric, this enleanment results in reduced exhaust HC and CO but causes an increase in vehicle nitrogen oxide (NO_x) emissions.

A closed-loop vehicle with an operating oxygen sensor in control of the engine will try to compensate for the oxygen present in the fuel by increasing the fuel flow until stoichiometry is achieved. If its fuel system has the necessary range of control authority, such a vehicle experiences little or no enleanment due to the blend for those portions of vehicle operation when the oxygen sensor is functioning and in control of the engine. Thus, one expects a smaller absolute reduction in exhaust HC and CO emissions from vehicles with oxygen sensors (generally 1981 and later model years) than earlier model year vehicles and perhaps a smaller proportional reduction as well. It should be noted, however, that a closed-loop vehicle produces most of its CO during its occasional open-loop modes of operation.

The reductions in HC and CO are generally greater for vehicles at high altitude since a given volume of air at high altitude has lower density and less oxygen. Open-loop vehicles operate richer more often and to a greater degree than they would at low altitude which results in greater grams per mile emission reductions due to the enleanment. The same holds for closed-loop vehicles during their open-loop modes.

Various organizations have done extensive tests under low altitude conditions on oxygenated blends providing a large data base that can be used to quantify the effects of these blends on emissions. Only the Colorado Department of Health has conducted and published data from exhaust emission tests on numerous vehicles at high altitude.

EPA has reviewed the available data and performed several statistical analyses to better quantify these emission effects. Table 3-1 lists the exhaust emission changes expected with oxygenated blends for fuels with 3.7% oxygen (gasohol or methanol blends) and 2% oxygen (an 11% MTBE blend). The separate low and high altitude data bases indicate essentially the same CO effect of blends on a percent basis, as shown in the table. Since the effect of altitude on HC and NO_x emissions is much less than on CO, and complete summaries of the high altitude HC and NO_x data have not been published, the percentage changes for low altitude have been used for the high altitude cases as well. Both CO and exhaust volatile organic compounds (VOC) decrease while NO_x increases. VOC, in effect, are the non-methane hydrocarbons with adjustments made to account for the lower photochemical reactivity of methanol, if present.

Only limited data are available for the closed-loop vehicles making these estimates more tentative. One very important point to note is that some, but not all, newer closed-loop vehicles are equipped with "adaptive learning." Properly functioning vehicles with adaptive learning continuously adjust their open-loop fuel calibrations based on the most recent period of closed-loop operation. Thus, they can compensate at least partially for fuel-caused enleanment even when the oxygen sensor is not in control, such as during cold starts and heavy accelerations. They may also not run as rich in failure modes as simpler closed-loop vehicles. These vehicles are expected to have lower exhaust CO (and HC) reductions than earlier closed-loop vehicles. These lower reductions expected for the adaptive learning vehicles may not be fully reflected in the limited test data available.

Also, increases in RVP, as can occur with ethanol blends that have not been adjusted to meet ASTM volatility specifications, cause an increase in exhaust emissions. For example, an increase in RVP of about 1 psi results in about a 3% increase in exhaust hydrocarbon emissions which is included in the one column of the above mentioned table.

3.1.1.2 Evaporative HC Emissions

Evaporative emissions consist of hot soak and diurnal emissions. Hot soak emissions occur during the period immediately following engine shut-down (i.e., at the end of each vehicle trip). These losses will originate from both the fuel metering system and from the fuel tank. These emissions are greater for carbureted vehicles than for vehicles with fuel injection. Diurnal emissions consist of hydrocarbons both evaporated and displaced from the vehicle's fuel tank as the vehicle tracks the diurnal swing in ambient temperatures. Each day, as the fuel in the tank and the vapor above the fuel heat up, more of the liquid fuel evaporates and the vapor itself expands, with both phenomena causing hydrocarbons to be released into the atmosphere.

MOBILE3 assumes that each vehicle makes 3.05 daily trips totalling 31.1 miles per day, so that there are 3.05 incidences of hot soak emissions for every diurnal emission. However, in reality, the relative number of hot soak and diurnal emissions vary with vehicle age since older vehicles are used for fewer daily trips (and also fewer miles but not in exact proportion) than newer vehicles. MOBILE4 will account for these differences. Also, local areas may in MOBILE4 be able to specify local factors. To account for this accurately in assessing alternate fuels would be very difficult with MOBILE3 and perhaps also in MOBILE4, and is beyond this document. This document uses the fixed weighting from MOBILE3 for all age vehicles.

This report gives data on evaporative emissions with both a low and high volatility fuel of 9 and 11.7 psi RVP. Fuel volatility varies from one part of the country to another. For example, in most areas of the country, the recommended ASTM RVP level during the summer months is generally 11.5 psi, although some areas have lower RVP but higher average temperatures and or higher altitude which lead to approximately equivalent emissions. For the purposes of this report, the 11.7 psi RVP fuel can be used for the 11.5 psi RVP case. The 9.0 psi RVP values are provided because EPA intends to propose a new limit of 9.0 psi that will apply for some years for which state and local planners will wish to estimate blend effects. These two cases are evaluated separately because evaporative emissions are a non-linear function of RVP. Thus, the effects at one RVP level could not be easily evaluated based on the effects at the other level.

Use of alcohol increases RVP compared to the base gasoline. Addition of ethyl alcohol (ethanol) results in an increase in RVP; since the resultant blend is not subject to ASTM RVP limits, the final blend will be about 1 psi higher in RVP and can exceed ASTM levels. (Claims by some of a significantly smaller RVP increase with ethanol are not consistent with the majority of the data in the literature.) Evaporative emissions from an ethanol blend are a mix of ethanol and gasoline vapors. It is important to note that equal RVP is assumed to result in equal moles of diurnal emissions; the lower molecular weight of ethanol (46) versus the typical evaporative hydrocarbon (64) results in slightly lower mass emissions. This factor has been accounted for in the tables.

Addition of ethanol to gasoline also changes the distillation curve of the fuel and, in particular, increases the percent evaporated at 160°F. The increase in the 160° point has been shown to result in an increase in hot soak evaporative emissions even though the fuel RVP is constant.[12]

Another important phenomenon to consider with gasohol blends is "commingling" which refers to the mixing of gasoline/alcohol blends with non-alcohol gasolines in vehicle fuel tanks whenever consumers switch from one fuel type to the other when refueling their vehicles at a service station. The resultant commingled blend consisting of a mixture of gasohol and gasoline will have a higher RVP level than the simple volume weighted average of the gasohol and gasoline. With 50% market penetration of gasohol and 50% gasoline, a maximum amount of commingling of the two different fuel types will occur. Table 3-2 gives these values for ethanol blends. If the market penetration of an ethanol blend is other than 50%, a commingling value should be determined by use of a quadratic equation through the three points given for 0%, 50%, and 100% market share. The subject of commingling is discussed in more detail later.

A final factor has been raised for ethanol blends concerning the relative reactivity of ethanol compared to hydrocarbons in either exhaust or evaporative emissions. Some smog chamber data have indicated that on a carbon-for-carbon basis ethanol is only slightly less reactive than the hydrocarbon compounds in exhaust and evaporative emissions.[22] This slight decrease in reactivity is not great enough to give a credit for "ozone" reduction for the ethanol content of either evaporative or exhaust emissions. However, ethanol has fewer carbon atoms per gram than gasoline vapor, so an adjustment for this has been incorporated into the evaporative VOC estimates.

3.1.2 Methanol Blends with 3.7% Oxygen

To date, two different waivers for methanol blends have been approved. The first is the ARCO Oxinol waiver for up to 4.75% methanol and 4.75% t-butanol as a cosolvent alcohol. This mixture has an oxygen content of 3.5%. Variations in the amount of the two alcohols are permitted as long as the methanol to cosolvent ratio is not over one to one (i.e., more methanol than cosolvent) and the total oxygen content does not exceed 3.5%. The second waiver is the DuPont waiver for a maximum of 5% methanol and a minimum of 2.5% cosolvent alcohol with a maximum total oxygen content of 3.7%. The cosolvent alcohols can be ethanol, propanols, or butanols. Use of 5% methanol and 2.5% ethanol results in an oxygen level of 3.7%. Use of propanols or butanols for cosolvents would result in lower oxygen levels if only 2.5% cosolvent alcohol were used.

3.1.2.1 Exhaust HC, CO and NOx Emissions

As mentioned before, the exhaust emission effect depends only on the fuel oxygen level and RVP. Therefore, Table 3-1 also applies to methanol blends. If either the DuPont or ARCO waiver blends are used in an oxygenated fuel program, it is important to have the program specify a minimum oxygen level. If the expected average oxygen level is less than 3.7%, the reduction in exhaust HC and CO emissions and the increase in NO_x emissions should be adjusted linearly from the values in Section 3.1.1.1 and Table 3-1.

3.1.2.2 Evaporative HC Emissions

Table 3-3 contains the evaporative emission effects of methanol blends, which do not depend on exact oxygen content.

Addition of methanol to a base gasoline generally results in an increase of 2-3 psi RVP. However, the resultant blend is subject to ASTM volatility parameters unlike gasohol. Thus, the volatility of the blend is adjusted (e.g., by prior butane removal) to decrease the volatility. For the purposes of this document, it can be assumed that the RVP of a methanol blend will be the same as that of the gasoline it displaces in the market place if gasoline in the area is on average about at the ASTM RVP limit. However, if various fuel surveys (such as the MVMA or NIPER summer surveys) show that gasoline in that area is under the ASTM limit (e.g., by about 1 psi), then the numbers in the tables for +1 psi RVP for either the 9 or 11.7 psi RVP cases should be used.

Both smog chamber and photochemical oxidant modeling data indicate that methanol is about 0.43 times as reactive as the hydrocarbons present in vehicle exhaust on a carbon-for-carbon basis. For the calculations this value is used. Also, the lower molecular weight of methanol versus gasoline evaporative hydrocarbons (32 versus 64) reduces the evaporative emissions and is included in Table 3-3. Evaporative emissions from a vehicle using a methanol blend consist of about 15% methanol, and methanol has approximately 0.44 times as many carbon atoms per gram as gasoline vapor. This results in a net reactivity 0.378 times that of gasoline vapor on a mass basis, which has been incorporated into the evaporative numbers in the tables.

If the market penetration of a blend is other than 50% or 100%, a commingling value should be determined by use of a quadratic equation through the three points given for 0%, 50%, and 100% market share. The subject of commingling is discussed in more detail later.

3.1.3 11% MTBE Blends (2% Oxygen)

While EPA has granted a waiver for use of 7% MTBE, EPA subsequently issued rules permitting use of oxygenates other than methanol in gasoline up to a level corresponding to 2% oxygen, ruling that such levels would be substantially similar to gasoline.[14] A 2% oxygen level would permit use of an 11% MTBE blend which is therefore the maximum level presently permitted. A new waiver application would have to be submitted to EPA and approved for use of higher MTBE levels.

3.1.3.1 Exhaust HC, CO, and NOx Emissions

It is assumed that the changes in exhaust emissions from use of 11% MTBE with a 2% oxygen level will be directly proportional to the amount of oxygen present. Thus, the values are a direct proportion of the earlier values for ethanol and methanol blends in Sections 3.1.1.1 and 3.1.2.1 and are shown in Table 3-1.

3.1.3.2 Evaporative HC Emissions

Addition of MTBE to gasoline does not result in increased RVP; in fact, some limited evidence indicates that there may be a slight decrease in RVP. However, 11% MTBE will increase the 160° point.[15] This results in increased evaporative emissions as mentioned in Section 3.1.1.2.[2] Values for this emission impact are given in Table 3.4.

3.1.4 Simultaneous Marketing of Ethanol, Methanol and MTBE Blends

The emission impact for partial marketing of only a single blend can be handled easily as explained above and also later. The exhaust and evaporative emission impact can be calculated using the appropriate tables. The factor for commingling included in the tables is relatively straightforward for a single blend.

However, simultaneous marketing of several different types of blends with or without gasoline also being sold raises the possibility of different types of commingling, such as of one blend with another. However, estimates of the commingling effects are available for only blends with gasoline and not one blend with another blend. Some simplifying assumptions are needed to approximate the effects of such cross-blend commingling. It will be assumed that MTBE blends always act like gasoline when commingled. For example, commingling of an MTBE blend with an ethanol blend would have the same effect on RVP as commingling of a gasoline with an ethanol blend. It will also be assumed that when an ethanol blend is commingled with a methanol blend that the ethanol blend acts like gasoline; i.e., it undergoes a sizable RVP boost. Appendix A provides a specific method to predict the emission changes due to commingling if a large fraction share of both methanol and ethanol blends are expected to be used.

3.2 Compressed Natural Gas (CNG) Vehicles

Compressed Natural Gas (CNG) consists mainly of methane with smaller quantities of ethane and propane. Very limited data suggest a large fraction (approximately 80%) of methane in the exhaust. Since methane is photochemically non-reactive, a potential exists for lower ozone formation from the exhaust emission products. Also, the combustion characteristics of CNG (e.g., leaner flammability limits, better mixing with the intake air for combustion) could lead to both lower HC and CO emissions. The limited data from several different studies on NO_x emissions with CNG are conflicting. While some data indicate that a decrease of NO_x up to 20% might occur, the majority of the data indicate an increase (up to 80%) with CNG. Due to the leaner combustion as well as methane's relatively high flame temperature, an increase in NO_x would be expected.

Most of the work done so far has been on retrofitting gasoline fueled vehicles to operate on CNG. Limited consideration has been given to manufacturing new vehicles designed to operate specifically on CNG. This section discusses factors affecting the retrofit scenario in some detail. The

changes in emissions for CNG vehicles given later though would apply to both new and retrofitted vehicles. Very limited data are available on emissions from CNG vehicles, however, so the numbers given in this section would have to be updated as more data become available. EPA would consider using different credits if adequate data are available to support them.

While numerous firms produce and market kits for converting gasoline vehicles to operate on either gasoline or CNG, very little reliable data on emissions of converted vehicles on CNG and gasoline have been obtained. There is some reason to suspect that some kits, when installed improperly, may result in increases in emissions when operated on gasoline, and emissions on CNG which are not significantly lower if at all. However, if an area were to make CNG conversions a significant part of its attainment strategy it would be appropriate and quite feasible to ensure that only proven-effective kits are used and that only competent mechanics install them.

Also, CNG can result in a deterioration of driveability and a power loss. Fleet operators may readjust the vehicles for richer operation to improve driveability. Thus, it would be necessary to have a procedure implemented with CNG use assuring that vehicles remain correctly adjusted. EPA would be available to give advice in this regard, and may at a later date even require or recommend specific safeguards and specifications for large-scale conversion programs if they are to be part of an approvable SIP. Therefore, for planning purposes this document assumes that emissions of all types of gasoline vehicles will be reduced by the following percentages when operating on CNG. Due to the limited nature of the data used for making these estimates, EPA plans to revise these estimates as more data become available. Due to lack of high altitude data, it can be assumed for now that the same percentage changes apply to both low and high altitude.

HC Exh:	-40%	(Includes effect of reduced reactivity)
CO:	-50%	
NOx:	+40%	(NO_x emissions generally increase with CNG and this number is an average of the data range)
HC Evap:	-100%	(assumes no evaporative emissions)

EPA will allow areas to assume that emissions when operating on gasoline are not affected by conversion.

In any practical conversion program most conversions will likely be of new or fairly young vehicles, since these are the types operated by self-fueling fleets and since the economics of conversion are more favorable the longer vehicles will remain in service. Although the available data are mostly from light-duty trucks and vehicles, EPA believes that the above percentage reductions may be reasonably appropriate for conversions of recent and future technology gasoline-fueled passenger cars, light-duty trucks and vans, and heavy-duty trucks and buses. Furthermore, these percentage reductions are assumed to apply at all ages. Very limited data are available on emissions from CNG vehicles, however, so the numbers given in this section would have to be updated as more data become available. EPA would consider using different credits if adequate data are available to support them.

3.3 Flexible Fuel Vehicles

Flexible fueled vehicles (FFVs) can use either gasoline fuel or a methanol/gasoline blend up to 85% or 100% methanol. The vehicles are designed to sense how much methanol is in the mixture and make appropriate engine adjustments for proper combustion. The use of methanol results in less reactive hydrocarbon emissions due to the low reactivity of the methanol. However, the presence of gasoline in the blend results in significant hydrocarbon emissions too. Data are not sufficient to indicate that either CO or NO_x emissions are changed with use of a flexible fueled vehicle.[16,17,18,19,20]

It is important when assigning emission reductions for flexible fueled vehicles to determine what fraction of the time the vehicle operates on a methanol mixture versus gasoline since no emission reductions occur with use of gasoline. It is also important to confirm what percentage methanol is being used. Items such as methanol sales records should be used for tracking purposes to determine the mileage accumulated with the methanol blends. Although there are no firm data to determine how much HC reduction should be assumed for a flexible fueled vehicle, EPA is willing to assign the same percentage reduction for a flexible fueled vehicle using 85% methanol as for a conventional technology vehicle designed for dedicated methanol use as mentioned in the next section. The following emission reduction credits (assumed to occur over the life of the vehicle) can be taken for the fraction of time a flexible fueled vehicle operates on 85% or higher methanol.

HC Exhaust - 21%

HC Evaporative - 54%

If there is an expectation of the vehicles operating on a methanol blend lower than 85%, the reduction above for 85% should be linearly proportioned.

There is a possibility that an advanced technology version of an FFV may exist in the future (see Section 3.4.2 below). Obstacles that reduce this possibility include the large differences in exhaust temperature of gasoline versus methanol and the dilemma this poses with respect to catalyst design and placement. However, since it may be possible to have an advanced technology FFV, EPA should be consulted regarding appropriate credit if such vehicles are contemplated.

Although emission data for flexible fueled vehicles are extremely limited at this time, EPA is aware of several on-going emission characterization programs. Any new data will be used to modify the above estimates, as appropriate. EPA would consider using different credits if adequate data are available to support them.

The HC reductions given above (and those presented below in Sections 3.4.1 and 3.4.2) are based on an assumption that on a per carbon atom basis, each methanol molecule in the exhaust or evaporative emissions is only 43% as reactive as an average non-methane HC molecule emitted by a gasoline-fueled vehicle. This reactivity factor is based on the average effective reactivity determined from city-specific EKMA modeling of a number of different cities, which gave closely similar results for each city. Areas that have Airshed modeling that would allow them to develop customized reactivity adjustment factors for their local conditions consistent with EPA methods can use these factors to recalculate the effective reduction in VOC emissions instead of using the EPA reductions given above.

3.4 Dedicated Methanol Vehicles

A dedicated methanol vehicle is one that uses only fuel composed of at least 85% methanol. Even though the comments EPA received in response to its proposed methanol rulemaking indicated that such vehicles could realize most cost and performance advantages by using as little as 50% methanol, the vehicles currently being considered use from 85% to 100% methanol. This section gives two classes of methanol fueled vehicles, current and advanced technology. A current technology vehicle would be one designed with present technology for 85% or more methanol.

An advanced technology vehicle is one that would have very low emissions and high fuel economy through the use of engine design features optimized to take full advantage of pure methanol's excellent combustion characteristics (high octane, wide flammability limits, high flame speed, low flame temperature, etc.). Design features would likely include high compression, lean burn combustion, and an advanced fuel injection system, and could include concepts such as turbocharging or supercharging, methanol dissociation, cooling system modification, etc. Also, the advanced technology vehicle would have very low formaldehyde emissions possibly due to use of a modified catalyst configuration (size, composition, or location). The vehicle would have to be designed to have good driveability even though it would be leaned out enough to have sufficiently low NO_x emissions without the use of a reduction catalyst. Very limited data are available on emissions from methanol fueled vehicles; the numbers given in Sections 3.4.1 and 3.4.2 would have to be updated as more data become available. EPA would consider using different credits if adequate data are available to support them.

Various reference documents were used to compile the emission reduction figures given in Section 3.4.1 and 3.4.2.[16,17,18,19,20] Also, as with FFVs, areas that have Airshed modeling that would allow them to develop customized reactivity adjustment factors for their local conditions consistent with EPA methods can use these factors to obtain the effective reduction in VOC emissions instead of using the EPA reductions presented here.

3.4.1 Current Technology

There is a relatively large emissions data base for current technology vehicles using at least 85% methanol. In view of these data EPA expects that current technology methanol vehicles would emit an equivalent amount of organic emissions as current gasoline vehicles considering the amount of carbon. That is, 0.41 g/mile HC standard represents 0.354 g/mile carbon assuming a carbon hydrogen ratio of 1:1.85. A methanol-fueled vehicle would also have a standard so that the organics contained no more than 0.354 g/mile carbon. As discussed earlier, methanol vehicle emissions as a whole are less reactive than gasoline vehicle emissions. Based on current EPA models, the emission reductions for current technology vehicles would be as follows.

HC Exhaust	- 21%
HC Evaporative	- 54%

This emission reduction is assumed to apply over the life of the vehicle. Arrangements should be made to collect fuel sales or similar records to later substantiate the credit claimed.

3.4.2 Advanced Technology

An advanced technology methanol vehicle would use technology such as described above to assure low emissions. To be classified as an advanced technology vehicle and receive the HC emission credit stated below, a vehicle would need to be certified to meet the following emission levels.

	Exhaust	Evaporative
HC	0.020 g/mile	0.0 g/test
Methanol	0.20 g/mile	1.0 g/test
Formaldehyde	0.003 g/mile	

The possibility of an advanced technology vehicle meeting a slightly higher evaporative emission level (2.0 g/ test of methanol) is also being considered. The above certification emission levels should result in the following in-use emission levels.

	In-Use Exhaust	In-Use Evaporative
HC	0.044 g/mile	0.0 g/mile
Methanol	0.44 g/mile	0.2 g/mile
Formaldehyde	0.007 g/mile	

A system should be set up to track in-use emissions from these vehicles to assure they meet the above levels in-use. An advanced technology methanol vehicle meeting these emission criteria could claim the following HC reduction credit.

HC Exhaust	- 86%
HC Evaporative	- 92%

These credits are based on the following calculations (with base gasoline vehicles having emission levels of 1.00 g/mile exhaust and 0.51 g/mile evaporative HC):

"Equivalent HC" g/mile = HC g/mile X HC reactivity factor
+ Methanol g/mile X Methanol reactivity factor*
+ Formaldehyde g/mile X Formaldehyde reactivity factor

Exhaust

"Equivalent HC" = 0.044 X 1.00
+ 0.44 X 13.9/32** X 0.43
+ 0.007 X 13.9/30** X 4.83

= 0.14 g/mile

Evaporative

"Equivalent HC" = 0.0 X 1.00
+ 0.20 X 14.3/32** X 0.43

= 0.04 g/mile

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* 49-state average reactivity values based on limited computer modeling. Area-specific reactivity factors may be used if available.

** Adjusts for carbon atoms/gram, since reactivity is on a per-carbon atom basis.

These numbers are very tentative ones and may change as more data are obtained. This reduction is assumed to apply over the useful life of the vehicle. However, following the introduction of the vehicle into the fleet some form of emissions monitoring would be needed to ensure that that there is no substantial in-use deterioration from these levels.

Also, if areas expect to have emission levels between the current and advanced technology cases presented above, EPA will accept reasonable estimates of in-use emissions to adjust the HC reduction accordingly. For example, a vehicle using 85% methanol could do better on some pollutants than the current technology levels but might have more hydrocarbons than allowed by the advanced technology standards. This vehicle could get some credit for lower emissions in one area than allowed by the current technology level. If, for example, such a vehicle had the following in-use emission levels (g/mile):

	In-Use Exhaust	In-Use Evaporative
HC	0.20 g/mile	0.07 g/mile
Methanol	0.75 g/mile	0.30 g/mile
Formaldehyde	0.05 g/mile	-

then the HC reduction credit could be calculated as follows (with base gasoline vehicles having emission levels of 1.00 g/mile exhaust and 0.51 g/mile evaporative HC):

Exhaust

"Equivalent HC" = 0.20 X 1.00
+ 0.75 X 13.9/32 X 0.43
+ 0.05 X 13.9/30 X 4.83

= 0.45 g/mile

Evaporative

"Equivalent HC" = 0.07 X 1.00
+ 0.30 X 14.3/32 X 0.43

= 0.13 g/mile

These yield the following HC reduction credits:

HC Exhaust - 55%

HC Evaporative - 75%

If this option is of interest, states should contact EPA to discuss the emission levels and reasonable estimates of in-use emissions. Possibly, this concept could also apply to Flexible Fueled Vehicles (FFVs).

4.0 CALCULATION OF FLEET EFFECTS

4.1 General Approach and Model Year-Specific Adjustment Factors

The general approach for calculating emission changes due to use of alternate fuels is based on MOBILE3 which is the model the States use to calculate the mobile source emission portion of their SIPs. MOBILE3 calculates emissions from in-use motor vehicles for the calendar year of interest. The purpose of this section is to present factors to adjust a special version of the MOBILE3 output to account for alternate fuels.

Before discussing the adjustment factors for MOBILE3, it is important to determine the technology split in the various vehicle classes. This technology split is important since the change in vehicle emissions with oxygenated fuels depends on the vehicle technology as mentioned in Section 3. Tables 4-1 and 4-2 list the technology splits for vehicles from the pre-1975 through 1990+ model years. The different technologies considered in Table 4-1 are non-catalyst, open-loop oxidation catalyst vehicles with carburetors, open-loop oxidation catalysts with fuel injection, closed-loop 3-way catalyst vehicles with carburetors, and closed loop 3-way catalyst vehicles with fuel injection. For exhaust emissions, it is a reasonable approximation to assume that a technology type's share of the model year's emissions is the same as its share of that year's sales. However, carbureted and fuel injected vehicles have quite different evaporative emissions. Greater accuracy can be achieved without undue complication by recognizing and accounting for this difference. Table 4-2 presents EPA's current best estimates of evaporative emissions from carbureted and fuel injected vehicles on 11.7 psi and 9.0 psi non-oxygenated gasoline.

Table 3-1 already listed the general percentage changes assigned to each technology class for exhaust emissions for ethanol, methanol, and MTBE blends. On a percentage basis these numbers are the same for low and high altitude, but since high altitude CO emissions are greater than low altitude, the g/mile changes would be greater at high altitude. Table 3-2 lists the evaporative emission assumptions by technology for ethanol blends. These changes were determined for each technology by adding the effects of RVP on diurnal and hot soak emissions as well as the effect of distillation curve (% evaporated at 160°F) on hot soak mass emissions. The distillation effect has been adjusted so as not to double count any RVP-only effect on hot soak emissions.

Ethanol Blends - The final results for ethanol blends are given in Tables 4-3 to 4-9, in the form of adjustment factors to be applied to individual model year emission levels of individual

vehicle types (e.g., LDGV, LDGT, etc.). Table 4-3 contains the percentage change in exhaust "volatile organic compounds" (or, for the purposes of MOBILE3, exhaust non-methane HC) for vehicles in model years pre-1975 through 1990+. Tables 4-4 through 4-7 list similar information for vehicles in these model years for vehicle evaporative emissions when using ethanol blends. Factors such as the RVP level of the blend and percent market share of the blend (i.e., the commingling effect for either 50% or 100% market share) are included in these tables. Tables 4-8 and 4-9 give exhaust CO and NO_x emissions changes with ethanol blends.

These tables were constructed using the individual technology effects from Tables 3-1 and 3-2 and weighting those effects by the technology mix (non-catalyst/OL/CL for exhaust, Carb/FI for evap) for each model year for each vehicle category (LDGV, LDGT1, LDGT2, and HDGV).

Methanol Blends - Since the exhaust effects of methanol blends are the same as for ethanol blends at a given RVP, Tables 3-1, 4-3, 4-8, and 4-9 also apply to methanol blends. Regarding evaporative emission effects, Tables 3-3 and 4-10 through 4-13 give similar information for methanol blends.

MTBE Blends - Tables 3-1, 3-4 and 4-14 through 4-17 give the corresponding exhaust and evaporative emission information for MTBE blends.

CNG and Methanol - Because the adjustments for CNG vehicles, FFV's, and current technology and advanced technology dedicated methanol vehicles do not depend on the technology mix of gasoline vehicles, they do not depend on model year. Therefore, separate tables like Table 4-3 are not shown for these alternate fuel cars. The general approach is the same, however. Appropriate adjustment factors for each affected model year should be taken from the relevant text in Section 3.

These calculations apply to both low and high altitude areas. However, for high altitude areas, the high altitude input flag of MOBILE3 should be used.

To use the information in, for example, Table 4-3 to calculate an overall fleet effect, it is necessary to first obtain a special MOBILE3 output showing model year-specific g/mile emission levels and VMT weighting factors. Then the model year adjustment factors from the appropriate table should be applied to the individual model year output for oxygenated blends. This must be repeated for each vehicle type. The model year factors should then be recombined across model years and then vehicle types. For both steps, VMT weighting factors are used. This adjustment and recombination procedure requires hand calculation.

This methodology will work for 100% of one or some model years using CNG, FFV, 85% methanol, or 100% methanol. It will also work for the oxygenated blends for the cases for which there are tables. These cases include 100% market share of one of the three oxygenate blends or 50% market share of either the ethanol or methanol blends. Other cases are covered in Appendix A.

4.2 Partial Penetration by One Blend or Vehicle Type

For market shares of oxygenated blends not listed in the table, the effects of the blends on evaporative emissions must be calculated. This calculation is simplest for MTBE where one can interpolate linearly for the effects between 0% and 100%, since there are no commingling effects. For either the ethanol or methanol blends, one must make a quadratic interpolation using the 0%, 50%, and 100% points since this relationship is not linear due to commingling effects.

It is important to note that the 50% market penetration of an ethanol or methanol blend results in a greater per-vehicle effect on evaporative VOC for the blend fueled fraction of the fleet than the 100% market share case. This can be seen by comparing Tables 4-4 and 4-6. The reason for this is that with an ethanol or methanol blend market share of less than 100% some degree of commingling is expected from consumers mixing the alcohol blend with either straight gasoline or a gasoline-MTBE blend (such as by filling their tank with an MTBE blend when the previous fill-up was with an ethanol blend). Therefore, a program with no commingling would yield the greatest benefits.

If the blend market share varies by model year or vehicle type, the user must interpolate the adjustment factors before they are applied to the model year g/mile emission levels. If it is the same for each model year and vehicle type, a single interpolation on the overall fleet emission level is acceptable.

If one blend or vehicle type (e.g., CNG, methanol) is used for only some model years, the adjustment should be applied only for those model years. Interpolation may be needed for that model year if there is less than 100% usage.

For partial penetration of alternate fuel vehicles (e.g., CNG, methanol), one can proportion the adjustment factors or the final fleet g/mile value accordingly.

4.3 Simultaneous Marketing of MTBE, Ethanol, and/or Methanol Blends

A somewhat more complicated calculation procedure will be used for simultaneous use of different blends to account for commingling of the different oxygenates. In effect, MTBE blends will be considered the same as gasoline since commingling effects between MTBE blends and gasoline would not be expected to occur. Thus, if only MTBE blends and ethanol or methanol blends are being used, the above procedure can be used with a simple modification as described in the following example.

Suppose the gasoline market share is 50%, the MTBE blend (2% oxygen) share is 15%, and the ethanol blend share (3.7% oxygen) is 35%. Three fleet gram/mile emission factors must be calculated.

(1) One with model year adjustment factors equal to 0.15 times the 100% market share MTBE adjustment factors in Table 4-17. (Zero ethanol sales)

(2) One with model year adjustment factors equal to 0.15 times the 100% market share MTBE adjustment factors in Table 4-17 plus 0.85 times the 50% market share ethanol adjustment factors in Tables 4-6 and 4-7.

(3) One with adjustment factors equal to 0.15 times the 100% market share MTBE factors from Table 4-17 plus 0.85 times the 100% market share ethanol adjustment factors in Tables 4-4 and 4-5.

The three fleet emission factors at 0%, 50%, and 100% ethanol market shares must then be interpolated to 35% market share using a quadratic interpolation as mentioned in Section 4.2.

If both ethanol and methanol blends are being marketed, the calculation procedure becomes a little more complex and is described in Appendix A.

4.4 Blends and CNG, FFV, M85 and/or M100 in Same Model Year

Here each model year should be divided into two or more groups based on the sales split between gasoline vehicles and alternate fuel vehicles. An adjustment factor should be selected (or calculated if necessary) for the gasoline portion based on expected blend use. This adjustment factor should be combined with the standard adjustment factors for CNG, FFV, current technology methanol vehicles, and advanced technology methanol vehicles using the new vehicle sales mix.

5.0 OBTAINING SPECIAL MOBILE3 OUTPUT

To use the method and numerical adjustment factors provided in earlier sections, it is necessary to have more detailed output than can be obtained with the standard MOBILE3 (or MOBILE4) program. Specifically, output is needed which shows for a given pollutant the emission factor for each model year/vehicle type, and that model year's share of the VMT from that vehicle type. VMT shares among vehicle types are also needed but are available in the standard MOBILE3 output. For VOC, exhaust and evaporative emissions must be shown separately for each model year so that the separate adjustments can be made.

While it is possible for a user to modify the MOBILE3 code to generate the required output, EPA believes it will be more convenient and less error prone for most users to obtain from EPA a magnetic tape containing the Fortran source code for a modified MOBILE3 which can produce both the standard types of output and the special version required for using this method. Users should contact (name and telephone to be provided in final document only).

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17. "Assessment of Emissions from Methanol-Fueled Vehicles: Implications for Ozone Air Quality", R.J. Nichols and J.M. Norbeck, Air Pollution Control Association Paper 85-38.3, June 1985.

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21. ARCO Letter on commingling and fuel volatility from W.J. Wostl to Charles L. Gray, EPA, February 4, 1985.

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Table 3-1

Technology-Specific
Exhaust Effects of Blends
Percent Change from Gasoline
(low and high altitude)

Technology	3.7% Oxygen (10% Ethanol or 5% Methanol/Cosolvent Blends)				2.0% Oxygen (11% MTBE Blends)		
			VOC				VOC
	CO	NOx	Same RVP	+1 PSI	CO	NOx	Same RVP
Non-Catalyst	-18.0	+4.8	-8.5	-6.7	-9.7	-2.6	-4.6
Open-Loop Catalyst (carbureted)	-30.0	+4.8	-8.5	-6.7	-16.6	+2.6	-4.6
Closed-Loop (carbureted)	-10.0	+6.3	-4.4	-0.7	-5.4	+3.4	-2.4
Closed-Loop (fuel injected)	-10.0	+6.3	-4.4	-0.7	-5.4	+3.4	-2.4

Sources and Assumptions

Non-Catalyst CO (-18%) - Based on the differences in mean CO of a group of high altitude vehicles tested on 0% and 3.7% oxygen fuels. No low altitude test data were located for non-catalyst vehicles. The 2% oxygen case is proportioned.

Open-Loop Catalyst CO (-30%) - The 30% reduction estimate is both the change in mean CO emissions of a group of high altitude vehicles, and the regression-based effect estimate from the complete sample (Table 2) of Reference 8. The 2% oxygen case is proportioned.

Closed-Loop Carbureted/FI CO (-10%) - The 10% estimate reflects a judgmental adjustment of the available test data. The mean change in a group of high altitude vehicles was -18%, but the group may not have had emission levels representative of the bulk of the in-use vehicles for which this estimate will apply in the post-1987 period, and may not have been tested in a way which allowed adaptive memory to limit the CO benefit as much as it would for in-use vehicles. The regression-based effect estimate using the complete sample of low altitude vehicles in Reference 8 would be -13%, but is also subject to concerns about representativeness. The lower figure of 10% was selected to avoid the risk of giving too much credit and of EPA approving SIP's which would later prove inadequate in practice. The 2% oxygen case is proportioned.

Sources and Assumptions (continued)

NOx(+4.3, -6.3%) - The values shown are the regression-based effect estimates for the complete sample of low altitude test vehicles from Reference 8 (Table 2). The open-loop catalyst estimate was used for non-catalyst vehicles for lack of other data. The closed-loop NOx effect estimate was not judgmentally adjusted. The 2% oxygen case is proportioned.

Same RVP VOC, all technologies - Same source and method as for NOx.

-1PSI VOC, all technologies - Same source and methods as for NOx, but includes the RVP effect from Table 6 of Reference 8.

Table 3-2

Evaporative VOC Technology-Specific
Effects of 10% Ethanol Blends[a]
Percent Change From Gasoline

100% Share (no commingling)	11.7 RVP Base		9.0 RVP Base	
	Same RVP	RVP + 1	Same RVP	RVP - 1
Diurnal				
Carb	-6.5	+81.7	-6.5	+34.6
F.I.	-6.5	+106.4	-6.5	+32.9
H. S.				
Carb	+17.2	+46.4	+17.2	+34.2
F. I.	-3.8	+31.7	-3.8	-57.5
50% Share (max commingling)				
Diurnal				
Carb	+1.9	+95.5	-4.0	+42.3
F. I.	+2.5	+126.8	-4.7	+40.5
H. S.				
Carb	+21.1	+50.9	+18.8	+39.1
F. I.	+0.8	+36.8	+3.15	+63.7

a These effects include adjustments for lower molecular weight of ethanol and lower number of carbons/gram relative to gasoline vapor. For hot soak, adjustments for molecular weight are not used, but for carbureted vehicles an adjustment for distillation (% evap @160°F) is included.

6/4/87

Table 3-3

Technology-Specific Effects of 3.7% Oxygen Methanol/Cosolvent Blends: Evaporative VOC[a]

(percent change including reactivity adjustment)

100% Share (no commingling)	11.7 RVP Base: Same RVP	11.7 RVP Base: RVP + 1	9.0 RVP Base: Same RVP	9.0 RVP Base: RVP + 1
Diurnal				
Carb	-18.8	+57.8	-18.8	+16.9
F.I.	-18.8	+79.2	-18.8	+15.4
H.S.				
Carb.	-3.2	+20.1	-3.2	+9.0
F.I.	-12.2	+20.2	-12.2	-43.7
50% Share (Max Commingling)				
Diurnal				
Carb	+5.7	+112.1	-9.5	+39.9
F.I.	-10.7	+148.5	-11.4	+46.0
H.S.				
Carb	+7.9	+33.3	+2.1	+22.6
F.I.	+0.8	+34.8	+1.3	-75.3

a These effects include adjustments for lower molecular weight of methanol and lower number of carbons/gram relative to gasoline vapor. For hot soak, adjustments for molecular weight are not used, but for carbureted vehicles an adjustment for distillation (% evap @160°F) is included. The no commingling scenarios are based on Reference 2, and the maximum commingling scenarios adjust the no commingling estimates per Reference 21 assuming 20% full tanks at refueling and a reasonable degree of brand loyalty.

7/13/87

Table 3-4

Technology-Specific Effects of
11% MTBE Blends: Evaporative VOC[a]

(percent change, any base RVP)

Diurnal	
Carbureted	+1.8
Fuel Injected	+1.8
H.S.	
Carbureted	+12.8
Fuel Injected	-1.9

a These effects include adjustments for greater molecular weight of MTBE and lower number of carbons/gram relative to gasoline vapor. For hot soak, adjustments for molecular weight are not used, but for carbureted vehicles an adjustment for distillation (% evap @160°F) is included.

6/10/87

Table 4-1

Exhaust and Evaporative Emissions
Technology Mix (Sales-Based)

Model Year	Technology Mix*			
	LDGV	LDGT1	LDGT2	HDGV
	A/B/C/D/E	A/B/C/D/E	A/B/C/D/E	A/B
pre-1975	100/0/0/0/0	100/0/0/0/0	100/0/0/0/0	100/0
75	20/75/5/0/0	30/70/0/0/0	100/0/0/0/0	100/0
76	15/80/5/0/0	20/80/0/0/0	100/0/0/0/0	100/0
77	15/80/5/0/0	25/75/0/0/0	100/0/0/0/0	100/0
78	10/85/5/0/0	25/75/0/0/0	100/0/0/0/0	100/0
79	10/85/5/0/0	20/80/0/0/0	0/100/0/0/0	100/0
80	5/83/7/5/0	20/79/1/0/0	0/100/0/0/0	100/0
81	0/28/0/63/9	0/96/1/3/0	0/100/0/0/0	100/0
82	0/33/0/50/17	0/79/1/20/0	0/100/0/0/0	100/0
83	0/24/0/48/28	0/70/0/30/0	0/90/0/10/0	100/0
84	0/6/0/55/39	0/72/0/26/2	0/72/0/26/2	100/0
85	0/6/0/39/55	0/63/0/25/12	0/63/0/25/12	100/0
86	0/7/0/26/67	0/41/9/15/35	0/41/9/15/35	100/0
87	0/1/0/24/75	0/14/5/13/68	0/14/5/13/68	26/74
88	0/1/0/21/79	0/14/5/13/68	0/14/5/13/68	26/74
89	0/1/0/16/84	0/14/5/13/68	0/14/5/13/68	26/74
90+	0/1/0/10/89	0/14/5/13/68	0/14/5/13/68	26/74

* A Non-catalyst
B Open-loop carbureted
C Open-loop fuel injected
D Closed-loop carbureted
E Closed-loop fuel injected.

7 07 87

Table 4-2

Baseline Non-Oxygenated
Gasoline Evaporative HC Emissions

	RVP			
	9.0	10.0	11.7	12.7
Carbureted				
Hot Soak, g	2.42	2.88	4.44	5.85
Diurnal, g	2.73	2.93	9.69	13.82
Total, g/mile	0.33	0.41	0.75	1.18
Fuel Injected				
Hot Soak, g	0.87	1.43	2.75	3.76
Diurnal, g	1.86	2.65	8.99	19.83
Total, g/mile	0.15	0.23	0.56	1.01

Table 4-3

Low and High Altitude Adjustment Factors for 10% Ethanol or 3.7% Oxygen Methanol Blends by Model Year and Type: Exhaust VOC

	Matched RVP				RVP + 1.0 psi			
MY	LDGV	LDGT1	LDGT2	HDGV	LDGV	LDGT1	LDGT2	HDGV
pre-75	0.9150	0.9150	0.9150	0.9150	0.9330	0.9330	0.9330	0.9330
75	0.9193	0.9150	0.9150	0.9150	0.9364	0.9330	0.9330	0.9330
76	0.9193	0.9150	0.9150	0.9150	0.9364	0.9330	0.9330	0.9330
77	0.9193	0.9150	0.9150	0.9150	0.9364	0.9330	0.9330	0.9330
78	0.9193	0.9150	0.9150	0.9150	0.9364	0.9330	0.9330	0.9330
79	0.9193	0.9150	0.9150	0.9150	0.9364	0.9330	0.9330	0.9330
8	0.9230	0.9159	0.9150	0.9150	0.9407	0.9337	0.9330	0.9330
81	0.9445	0.9171	0.9150	0.9150	0.9762	0.9355	0.9330	0.9330
82	0.9425	0.9241	0.9150	0.9150	0.9732	0.9457	0.9330	0.9330
83	0.9462	0.9273	0.9191	0.9150	0.9786	0.9510	0.9390	0.9330
84	0.9535	0.9265	0.9265	0.9150	0.9894	0.9498	0.9498	0.9330
85	0.9535	0.9302	0.9302	0.9150	0.9894	0.9552	0.9552	0.9330
86	0.9531	0.9432	0.9432	0.9150	0.9888	0.9690	0.9690	0.9330
87	0.9556	0.9525	0.9525	0.9150	0.9924	0.9850	0.9850	0.9330
88	0.9552	0.9525	0.9525	0.9150	0.9923	0.9850	0.9850	0.9330
89	0.9552	0.9525	0.9525	0.9150	0.9923	0.9850	0.9850	0.9330
90+	0.9556	0.9525	0.9525	0.9150	0.9924	0.9850	0.9850	0.9330

Table 4-4

Low and High Altitude Adjustment Factors for 10%
Ethanol Blends by Model Year and Type: Evaporative VOC

(100% Use of Blend)

	9.0 psi			11.7 psi		
MY	LDGV	LDGT1,2	HDGV	LDGV	LDGT1,2	HDGV
pre-75	1.1077	1.1077	1.1077	1.0730	1.0730	1.0730
75	1.1041	1.1077	1.1077	1.0683	1.0730	1.0730
76	1.1041	1.1077	1.1077	1.0683	1.0730	1.0730
77	1.1041	1.1077	1.1077	1.0683	1.0730	1.0730
78	1.1041	1.1077	1.1077	1.0683	1.0730	1.0730
79	1.1041	1.1077	1.1077	1.0683	1.0730	1.0730
80	1.1026	1.1070	1.1077	1.0664	1.0721	1.0730
81	1.1011	1.1070	1.1077	1.0644	1.0721	1.0730
82	1.0945	1.1070	1.1077	1.0564	1.0721	1.0730
83	1.0845	1.1077	1.1077	1.0449	1.0730	1.0730
84	1.0728	1.1063	1.1077	1.0326	1.0712	1.0730
85	1.0522	1.0987	1.1077	1.0134	1.0615	1.0730
86	1.0330	1.0669	1.1077	0.9977	1.0268	1.0730
87	1.0178	1.0218	1.1077	0.9866	0.9894	1.0730
88	1.0093	1.0218	1.1077	0.9808	0.9894	1.0730
89	0.9977	1.0218	1.1077	0.9734	0.9894	1.0730
90+	0.9848	1.0218	1.1077	0.9658	0.9894	1.0730

Table 4-5

Low and High Altitude Adjustment Factors for 10% Ethanol Blends by Model Year and Type: Evaporative VOC

(100% Use of Blend)

	9.0 + 1.0 psi			11.7 + 1.0 psi		
MY	LDGV	LDGT1,2	HDGV	LDGV	LDGT1,2	HDGV
pre-75	1.3433	1.3433	1.3433	1.6107	1.6107	1.6107
75	1.3463	1.3433	1.3433	1.6142	1.6107	1.6107
76	1.3463	1.3433	1.3433	1.6142	1.6107	1.6107
77	1.3463	1.3433	1.3433	1.6142	1.6107	1.6107
78	1.3463	1.3433	1.3433	1.6142	1.6107	1.6107
79	1.3463	1.3433	1.3433	1.6142	1.6107	1.6107
80	1.3475	1.3439	1.3433	1.6157	1.6114	1.6107
81	1.3488	1.3439	1.3433	1.6171	1.6114	1.6107
82	1.3542	1.3439	1.3433	1.6230	1.6114	1.6107
83	1.3626	1.3433	1.3433	1.6316	1.6107	1.6107
84	1.3723	1.3445	1.3433	1.6407	1.6121	1.6107
85	1.3894	1.3508	1.3433	1.6549	1.6193	1.6107
86	1.4054	1.3772	1.3433	1.6665	1.6450	1.6107
87	1.4180	1.4147	1.3433	1.6748	1.6727	1.6107
88	1.4251	1.4147	1.3433	1.6790	1.6727	1.6107
89	1.4347	1.4147	1.3433	1.6845	1.6727	1.6107
90+	1.4454	1.4147	1.3433	1.6902	1.6727	1.6107

Table 4-6

Low and High Altitude Adjustment Factors for 10% Ethanol Blends by Model Year and Type: Evaporative VOC

(50% Use of Blend)

	9.0 psi			11.7 psi		
MY	LDGV	LDGT1,2	HDGV	LDGV	LDGT1,2	HDGV
pre-75	1.1263	1.1263	1.1263	1.1309	1.1309	1.1309
75	1.1234	1.1263	1.1263	1.1266	1.1309	1.1309
76	1.1234	1.1263	1.1263	1.1266	1.1309	1.1309
77	1.1234	1.1263	1.1263	1.1266	1.1309	1.1309
78	1.1234	1.1263	1.1263	1.1266	1.1309	1.1309
79	1.1234	1.1263	1.1263	1.1266	1.1309	1.1309
80	1.1221	1.1257	1.1263	1.1248	1.1300	1.1309
81	1.1209	1.1257	1.1263	1.1230	1.1300	1.1309
82	1.1156	1.1257	1.1263	1.1158	1.1300	1.1309
83	1.1074	1.1263	1.1263	1.1052	1.1309	1.1309
84	1.0980	1.1251	1.1263	1.0940	1.1292	1.1309
85	1.0812	1.1190	1.1263	1.0764	1.1203	1.1309
86	1.0657	1.0932	1.1263	1.0621	1.0887	1.1309
87	1.0533	1.0566	1.1263	1.0520	1.0546	1.1309
88	1.0464	1.0566	1.1263	1.0468	1.0546	1.1309
89	1.0370	1.0566	1.1263	1.0400	1.0546	1.1309
90-	1.0265	1.0566	1.1263	1.0330	1.0546	1.1309

Table 4-7

Low and High Altitude Adjustment Factors for 10% Ethanol Blends by Model Year and Type: Evaporative VOC

(50% Use of Blend)

	9.0 + 1.0 psi			11.7 + 1.0 psi		
MY	LDGV	LDGT1,2	HDGV	LDGV	LDGT1,2	HDGV
pre-75	1.3992	1.3992	1.3992	1.6949	1.6949	1.6949
75	1.4031	1.3992	1.3992	1.7002	1.6949	1.6949
76	1.4031	1.3992	1.3992	1.7002	1.6949	1.6949
77	1.4031	1.3992	1.3992	1.7002	1.6949	1.6949
78	1.4031	1.3992	1.3992	1.7002	1.6949	1.6949
79	1.4031	1.3992	1.3992	1.7002	1.6949	1.6949
80	1.4048	1.3999	1.3992	1.7023	1.6959	1.6949
81	1.4065	1.3999	1.3992	1.7045	1.6959	1.6949
82	1.4136	1.3999	1.3992	1.7133	1.6959	1.6949
83	1.4247	1.3992	1.3992	1.7262	1.6949	1.6949
84	1.4375	1.4007	1.3992	1.7398	1.6970	1.6949
85	1.4600	1.4091	1.3992	1.7612	1.7077	1.6949
86	1.4811	1.4439	1.3992	1.7785	1.7462	1.6949
87	1.4978	1.4934	1.3992	1.7909	1.7877	1.6949
88	1.5071	1.4934	1.3992	1.7973	1.7877	1.6949
89	1.5198	1.4934	1.3992	1.8055	1.7877	1.6949
90+	1.5339	1.4934	1.3992	1.8140	1.7877	1.6949

Table 4-8

Low and High Altitude Adjustment Factors for 10% Ethanol or 3.7% Oxygen Methanol Blends by Model Year and Type: CO

MY	LDGV	LDGT1	LDGT2	HDGV
pre-75	0.8200	0.8200	0.8200	0.8200
75	0.7390	0.7360	0.8200	0.8200
76	0.7330	0.7240	0.8200	0.8200
77	0.7330	0.7300	0.8200	0.8200
78	0.7270	0.7300	0.8200	0.8200
79	0.7270	0.7240	0.7000	0.8200
80	0.7370	0.7270	0.7000	0.8200
81	0.8440	0.7090	0.7000	0.8200
82	0.8340	0.7430	0.7000	0.8200
83	0.8520	0.7600	0.7200	0.8200
84	0.8880	0.7560	0.7560	0.8200
85	0.8880	0.7740	0.7740	0.8200
86	0.8860	0.8270	0.8270	0.8200
87	0.8980	0.8770	0.8770	0.7312
88	0.8970	0.8770	0.8770	0.7312
89	0.8970	0.8770	0.8770	0.7312
90+	0.8980	0.8770	0.8770	0.7312

Table 4-9

Low and High Altitude Adjustment Factors for 10% Ethanol or 3.7% Oxygen Methanol Blends by Model Year and Type: NOx

MY	LDGV	LDGT1	LDGT2	HDGV
pre-75	1.0480	1.0480	1.0480	1.0480
75	1.0456	1.0480	1.0480	1.0480
76	1.0456	1.0480	1.0480	1.0480
77	1.0456	1.0480	1.0480	1.0480
78	1.0456	1.0480	1.0480	1.0480
79	1.0456	1.0480	1.0480	1.0480
80	1.0454	1.0475	1.0480	1.0480
81	1.0588	1.0480	1.0480	1.0480
82	1.0581	1.0505	1.0480	1.0480
83	1.0594	1.0525	1.0495	1.0480
84	1.0621	1.0522	1.0522	1.0480
85	1.0621	1.0536	1.0536	1.0480
86	1.0620	1.0512	1.0512	1.0480
87	1.0629	1.0578	1.0578	1.0480
88	1.0635	1.0578	1.0578	1.0480
89	1.0635	1.0578	1.0578	1.0480
90+	1.0629	1.0578	1.0578	1.0480

Table 4-10

Low and High Altitude Adjustment Factors for 3.7% Oxygen Methanol Blends by Model Year and Type: Evaporative VOC

(100% Use of Blend)

	9.0 psi			11.7 psi		
MY	LDGV	LDGT1,2	HDGV	LDGV	LDGT1,2	HDGV
pre-75	0.9260	0.9260	0.9260	0.9031	0.9031	0.9031
75	0.9242	0.9260	0.9260	0.9009	0.9031	0.9031
76	0.9242	0.9260	0.9260	0.9009	0.9031	0.9031
77	0.9242	0.9260	0.9260	0.9009	0.9031	0.9031
78	0.9242	0.9260	0.9260	0.9009	0.9031	0.9031
79	0.9242	0.9260	0.9260	0.9009	0.9031	0.9031
80	0.9235	0.9256	0.9260	0.8999	0.9027	0.9031
81	0.9228	0.9256	0.9260	0.8990	0.9027	0.9031
82	0.9197	0.9256	0.9260	0.8952	0.9027	0.9031
83	0.9148	0.9260	0.9260	0.8898	0.9031	0.9031
84	0.9092	0.9253	0.9260	0.8840	0.9022	0.9031
85	0.8994	0.9216	0.9260	0.8748	0.8976	0.9031
86	0.8902	0.9064	0.9260	0.8674	0.8812	0.9031
87	0.8829	0.8848	0.9260	0.8622	0.8635	0.9031
88	0.8788	0.8848	0.9260	0.8595	0.8635	0.9031
89	0.8733	0.8848	0.9260	0.8559	0.8635	0.9031
90+	0.8671	0.8848	0.9260	0.8523	0.8635	0.9031

Table 4-11

Low and High Altitude Adjustment Factors for 3.7% Oxygen Methanol Blends by Model Year and Type: Evaporative VOC

(100% Use of Blend)

	9.0 + 1.0 psi			11.7 + 1.0 psi		
MY	LDGV	LDGT1,2	HDGV	LDGV	LDGT1,2	HDGV
pre-75	1.1114	1.1114	1.1114	1.3579	1.3579	1.3579
75	1.1162	1.1114	1.1114	1.3636	1.3579	1.3579
76	1.1162	1.1114	1.1114	1.3636	1.3579	1.3579
77	1.1162	1.1114	1.1114	1.3636	1.3579	1.3579
78	1.1162	1.1114	1.1114	1.3636	1.3579	1.3579
79	1.1162	1.1114	1.1114	1.3636	1.3579	1.3579
80	1.1182	1.1123	1.1114	1.3659	1.3590	1.3579
81	1.1203	1.1123	1.1114	1.3682	1.3590	1.3579
82	1.1290	1.1123	1.1114	1.3778	1.3590	1.3579
83	1.1425	1.1114	1.1114	1.3916	1.3579	1.3579
84	1.1580	1.1133	1.1114	1.4063	1.3602	1.3579
85	1.1855	1.1234	1.1114	1.4293	1.3718	1.3579
86	1.2111	1.1659	1.1114	1.4481	1.4133	1.3579
87	1.2314	1.2261	1.1114	1.4613	1.4580	1.3579
88	1.2428	1.2261	1.1114	1.4682	1.4580	1.3579
89	1.2583	1.2261	1.1114	1.4771	1.4580	1.3579
90+	1.2755	1.2261	1.1114	1.4863	1.4580	1.3579

Table 4-12

Low and High Altitude Adjustment Factors for 3.7% Oxygen
Methanol Blends by Model Year and Type: Evaporative VOC

(50% Use of Blend)

	9.0 psi			11.7 psi		
MY	LDGV	LDGT1,2	HDGV	LDGV	LDGT1,2	HDGV
pre-75	0.9894	0.9894	0.9894	1.0697	1.0697	1.0697
75	0.9888	0.9894	0.9894	1.0693	1.0697	1.0697
76	0.9888	0.9894	0.9894	1.0693	1.0697	1.0697
77	0.9888	0.9894	0.9894	1.0693	1.0697	1.0697
78	0.9888	0.9894	0.9894	1.0693	1.0697	1.0697
79	0.9888	0.9894	0.9894	1.0693	1.0697	1.0697
80	0.9885	0.9893	0.9894	1.0691	1.0696	1.0697
81	0.9882	0.9893	0.9894	1.0690	1.0696	1.0697
82	0.9870	0.9893	0.9894	1.0683	1.0696	1.0697
83	0.9851	0.9894	0.9894	1.0673	1.0697	1.0697
84	0.9830	0.9892	0.9894	1.0663	1.0695	1.0697
85	0.9792	0.9878	0.9894	1.0646	1.0687	1.0697
86	0.9756	0.9819	0.9894	1.0633	1.0658	1.0697
87	0.9728	0.9736	0.9894	1.0624	1.0626	1.0697
88	0.9713	0.9736	0.9894	1.0619	1.0626	1.0697
89	0.9691	0.9736	0.9894	1.0613	1.0626	1.0697
90+	0.9668	0.9736	0.9894	1.0606	1.0626	1.0697

Table 4-13

Low and High Altitude Adjustment Factors for 3.7% Oxygen Methanol Blends by Model Year and Type: Evaporative VOC

(50% Use of Blend)

	9.0 + 1.0 psi			11.7 + 1.0 psi		
MY	LDGV	LDGT1,2	HDGV	LDGV	LDGT1,2	HDGV
pre-75	1.2725	1.2725	1.2725	1.6616	1.6616	1.6616
75	1.2808	1.2725	1.2725	1.6720	1.6616	1.6616
76	1.2808	1.2725	1.2725	1.6720	1.6616	1.6616
77	1.2808	1.2725	1.2725	1.6720	1.6616	1.6616
78	1.2808	1.2725	1.2725	1.6720	1.6616	1.6616
[illegible]	1.2808	1.2725	1.2725	1.6720	1.6616	1.6616
8[illegible]	1.2843	1.2741	1.2725	1.6762	1.6636	1.6616
8[illegible]	1.2878	1.2741	1.2725	1.6805	1.6636	1.6616
82	1.3028	1.2741	1.2725	1.6981	1.6636	1.6616
83	1.3260	1.2725	1.2725	1.7235	1.6616	1.6616
84	1.3527	1.2758	1.2725	1.7504	1.6657	1.6616
85	1.3999	1.2933	1.2725	1.7928	1.6870	1.6616
86	1.4440	1.3663	1.2725	1.8272	1.7632	1.6616
87	1.4790	1.4697	1.2725	1.8516	1.8454	1.6616
88	1.4985	1.4697	1.2725	1.8643	1.8454	1.6616
89	1.5251	1.4697	1.2725	1.8806	1.8454	1.6616
90+	1.5547	1.4697	1.2725	1.8974	1.8454	1.6616

Table 4-14

Low and High Altitude Adjustment Factors for
11% MTBE Blends by Model Year and Type: Exhaust VOC

MY	LDGV	LDGT1	LDGT2	HDGV
pre-75	0.9541	0.9541	0.9541	0.9541
75	0.9564	0.9541	0.9541	0.9541
76	0.9564	0.9541	0.9541	0.9541
77	0.9564	0.9541	0.9541	0.9541
78	0.9564	0.9541	0.9541	0.9541
79	0.9564	0.9541	0.9541	0.9541
80	0.9584	0.9545	0.9541	0.9541
81	0.9700	0.9552	0.9541	0.9541
82	0.9689	0.9589	0.9541	0.9541
83	0.9709	0.9607	0.9563	0.9541
84	0.9749	0.9603	0.9603	0.9541
85	0.9749	0.9623	0.9623	0.9541
86	0.9747	0.9693	0.9693	0.9541
87	0.9760	0.9743	0.9743	0.9541
88	0.9758	0.9743	0.9743	0.9541
89	0.9758	0.9743	0.9743	0.9541
90+	0.9760	0.9743	0.9743	0.9541

Table 4-15

Low and High Altitude Adjustment Factors for 11% MTBE Blends by Model Year and Type: Exhaust CO

MY	LDGV	LDGT1	LDGT2	HDGV
pre-75	0.9027	0.9027	0.9027	0.9027
75	0.8589	0.8573	0.9027	0.9027
76	0.8557	0.8508	0.9027	0.9027
77	0.8557	0.8541	0.9027	0.9027
78	0.8524	0.8541	0.9027	0.9027
79	0.8524	0.8508	0.8378	0.9027
80	0.8578	0.8524	0.8378	0.9027
81	0.9157	0.8427	0.8378	0.9027
82	0.9103	0.8611	0.8378	0.9027
83	0.9200	0.8703	0.8486	0.9027
84	0.9395	0.8681	0.8681	0.9027
85	0.9395	0.8778	0.8778	0.9027
86	0.9384	0.9065	0.9065	0.9027
87	0.9449	0.9335	0.9335	0.8547
88	0.9443	0.9335	0.9335	0.8547
89	0.9443	0.9335	0.9335	0.8547
90+	0.9449	0.9335	0.9335	0.8547

Table 4-16

Low and High Altitude Adjustment Factors for
11% MTBE Blends by Model Year and Type: Exhaust NOx

MY	LDGV	LDGT1	LDGT2	HDGV
pre-75	1.0259	1.0259	1.0259	1.0259
75	1.0246	1.0259	1.0259	1.0259
76	1.0246	1.0259	1.0259	1.0259
77	1.0246	1.0259	1.0259	1.0259
78	1.0246	1.0259	1.0259	1.0259
79	1.0246	1.0259	1.0259	1.0259
80	1.0245	1.0257	1.0259	1.0259
81	1.0318	1.0259	1.0259	1.0259
82	1.0314	1.0273	1.0259	1.0259
83	1.0321	1.0284	1.0268	1.0259
84	1.0336	1.0282	1.0282	1.0259
85	1.0336	1.0289	1.0289	1.0259
86	1.0335	1.0277	1.0277	1.0259
87	1.0340	1.0312	1.0312	1.0259
88	1.0343	1.0312	1.0312	1.0259
89	1.0343	1.0312	1.0312	1.0259
90+	1.0340	1.0312	1.0312	1.0259

Table 4-17

Low and High Altitude Adjustment Factors for
11% MTBE Blends by Model Year and Type: Evaporative VOC

MY	9.0 psi LDGV	9.0 psi LDGT1,2	9.0 psi HDGV	11.7 psi LDGV	11.7 psi LDGT1,2	11.7 psi HDGV
pre-75	1.0983	1.0983	1.0983	1.0822	1.0822	1.0822
75	1.0960	1.0983	1.0983	1.0790	1.0822	1.0822
76	1.0960	1.0983	1.0983	1.0790	1.0822	1.0822
77	1.0960	1.0983	1.0983	1.0790	1.0822	1.0822
78	1.0960	1.0983	1.0983	1.0790	1.0822	1.0822
79	1.0960	1.0983	1.0983	1.0790	1.0822	1.0822
80	1.0950	1.0979	1.0983	1.0778	1.0815	1.0822
81	1.0940	1.0979	1.0983	1.0765	1.0815	1.0822
82	1.0897	1.0979	1.0983	1.0713	1.0815	1.0822
83	1.0832	1.0983	1.0983	1.0637	1.0822	1.0822
84	1.0756	1.0974	1.0983	1.0556	1.0809	1.0822
85	1.0622	1.0925	1.0983	1.0430	1.0746	1.0822
86	1.0497	1.0717	1.0983	1.0327	1.0518	1.0822
87	1.0397	1.0424	1.0983	1.0254	1.0272	1.0822
88	1.0342	1.0424	1.0983	1.0216	1.0272	1.0822
89	1.0266	1.0424	1.0983	1.0167	1.0272	1.0822
90+	1.0182	1.0424	1.0983	1.0117	1.0272	1.0822

APPENDIX A

Instructions on Calculating Commingling Effects When Both Methanol and Ethanol Blends Are Used

Evaporative Emissions Increases from Commingling

Sections 3.1.2.2 and 3.1.4 mention that evaporative emissions increase when an alcohol-containing gasoline blend is mixed with gasoline in a vehicle's fuel tank. The increase is relative to what evaporative emissions would have been had the two fuels been used in separate vehicles or by one vehicle in succession with no mixing. This increase is, in effect, due to a non-linear increase in volatility from mixing the two different type fuels.

Mixing of MTBE blends with gasoline causes no extra increase in evaporative emissions due to commingling. Table 4-17 gives the increases (as multiplicative adjustment factors) in evaporative emissions with 100% use of an MTBE blend. The increase for evaporative emissions for MTBE usage below 100% should be linearly interpolated between the increase at zero market share and the increase given for the 100% market share case.

Mixing of ethanol blends with gasoline does result in extra evaporative emissions due to commingling. Thus, the increases in evaporative emissions with a 50% market share of ethanol blends is more than one-half the increase for a 100% market share. A similar situation exists for methanol blends.

If a market penetration of an alcohol blend is other than 50% or 100%, an adjustment value for evaporative emissions should be determined by use of quadratic equation through the three points given for 0%, 50%, and 100% market share. The 50% and 100% market share values are given in the tables mentioned in the previous paragraph. This methodology works when only a single alcohol blend is being marketed.

If a single alcohol blend is being marketed along with an MTBE blend, the MTBE blend should be assumed to act like gasoline when commingled. Thus, the market share of non-oxygenated gasoline and MTBE blends should be added together and used as described in the preceding paragraph and in Section 4.2.

If an ethanol blend and methanol blend are being marketed, the ethanol blend should be assumed to act like gasoline when commingled. Thus, the market shares of non-oxygenated gasoline and ethanol blends should be added together and used as described above to determine the commingling effect due to the methanol blend. Also, it will be necessary to determine the effect of commingling of the non-oxygenated gasoline and the

ethanol blends. The newly determined percentage increase values for the methanol and ethanol blends should be applied to the appropriate fraction of the market.

The narrative information in the above paragraphs can also be presented algebraically. The following fuel use scenarios are defined for use in the calculations.

Fuel Use Scenarios

A	non-oxygenated gasoline (Standard MOBILE3)
B	100% ethanol blends
C	50% ethanol blends
D	100% methanol blends
E	50% methanol blends
F	100% MTBE blends
G	w% non-oxygenated gasoline x% MTBE blends y% ethanol blends z% methanol blends w% + x% + y% + z% = 100%

Scenario G is the most general scenario for which a fleet emission factor may be required. The other scenarios are straightforward ones for which model year-specific adjustment factors are given in Section 4.

For a complicated case such as G, the following equation should be used to predict the adjustment factor (G_{ef}) to apply to a given model year/vehicle type's evaporative emission factor.

G_{ef} = (quadratic fit of the model year/vehicle type's adjustment factors for scenarios A, D, and E evaluated at z%) +

(the adjustment factor for Scenario F) (x/100) -

(1-z/[100-y]) (quadratic fit of the adjustment factors for Scenarios A, B, and C evaluated at y%)

The three lines of the above equation represent the effects due to methanol blends, MTBE blends, and ethanol blends. It should be noted that the term in the third line

(1 -z/[100 - y])

represents the fraction of the fuel subject to a commingling effect with ethanol.

The term

$$z/(100 - y)$$

represents the fraction of the non-ethanol fuel that is methanol and is therefore considered not to have an effect for commingling with the ethanol blend. Commingling of the methanol blends and ethanol blends has already been considered earlier (line 1) in the equation.

APPENDIX B

Formula for Quadratic Interpolation Based on Blend Market Share